

# Claims

[c1] 1. A system for of aligning a mask to a substrate comprising:  
an alignment fixture for temporarily holding said mask and said  
substrate in fixed positions relative to each other;  
means for holding said substrate by a bottom surface, said  
means for holding said substrate protruding through an  
opening in a table and an opening in said alignment fixture,  
said means for holding fixedly mounted on a stage assembly,  
said stage assembly moveable in first and second directions  
and rotatable about an axis relative to said table;  
means for temporarily affixing said alignment fixture containing  
said mask and said substrate to said table;  
means for controlling said means for temporarily affixing so as  
to generate a uniform force around a perimeter of said  
alignment fixture to effectuate said temporarily affixing;  
for aligning said mask to said substrate, said means for  
aligning controlling movement of said stage assembly in said  
first and second directions and rotation about said axis; and  
means for temporarily fastening said alignment fixture  
together.

[c2] The system of claim 1, wherein said first and second  
directions are orthogonal to each other and parallel to said  
table.

- [c3] The system of claim 1, wherein said axis is perpendicular to said table.
- [c4] The system of claim 1, further including an additional stage assembly moveable in said first and second directions, said stage assembly and said table mounted on said additional stage assembly, movement of said additional stage assembly in said first and second directions controlled by said means for aligning.
- [c5] The system of claim 1, wherein said means for holding said substrate is a vacuum chuck including a circular array of O-rings adjacent to a perimeter of said chuck, each O-ring extending above a top surface of said chuck and surrounding a vacuum port.
- [c6] The system of claim 5, further including means for releasing vacuum pressure applied to said vacuum chuck when said uniform force reaches a predetermined value.
- [c7] The system of claim 1, further including at least two mask alignment pin mechanisms, said mask alignment pin mechanisms mounted to said table and containing alignment pins, said alignment pins passing through alignment pin holes in said table and alignment pin holes in said alignment fixture and engaging mask alignment holes in said mask.
- [c8] The system of claim 7, wherein said alignment pins are spring

loaded and can move in a third direction perpendicular to said table.

- [c9] The system of claim 7, wherein said mask alignment holes comprise a circular alignment hole and a slot.
- [c10] 10. The system of claim 7, wherein said mask alignment holes are diametrically opposed.
- [c11] The system of claim 1, wherein said means for temporarily affixing are two or more clamping mechanisms uniformly spaced around a perimeter of said alignment fixture.
- [c12] The system of claim 11, wherein said clamping mechanisms further include clamping fingers for compressing and clamping said alignment fixture and push rods for moving said clamping fingers.
- [c13] The system of claim 12, wherein said push rods are simultaneously activated by a rotatable ring moveable in a third direction perpendicular to said table as said rotatable ring is rotated.
- [c14] The system of claim 1, wherein said means for temporarily fastening insert removable spring clips onto lower portions of retaining posts extending below a bottom ring of said alignment fixture, said retaining posts fixed in and extending from a top ring portion of said alignment fixture and through

retaining post holes in said mask and retaining post holes in said bottom ring.

- [c15] The system of claim 14, wherein said means for temporarily fastening simultaneously insert said removable spring clips onto said retaining posts.
- [c16] The system of claim 15, wherein said means for temporarily fastening compress said removable spring clips prior to insertion of said removable spring clips onto said retaining posts.
- [c17] The system of claim 1, wherein said means for aligning comprises a pattern recognition system including a camera and a computer, said pattern recognition system for determining locations of center points of alignment targets on said substrate and alignment marks on said mask relative to a fixed position of said stage assembly and for calculating a distance to move said stage assembly in said first direction, a distance to move said stage assembly in said second direction, and a angle to rotate said stage assembly through in order to align said center points of said alignment targets with said center points of said alignment marks.
- [c18] The system of claim 1, wherein said alignment fixture comprises:
  - a top ring;

a bottom ring having an inner lip for supporting an interior region of said substrate and an outer lip for supporting a peripheral region of said mask, said inner lip higher than said outer lip;  
retaining posts fixed in and extending from said top ring and through retaining post holes in said bottom ring;  
removable spring clips engaging said retaining posts;  
wherein said top ring presses said peripheral portion of said mask against said outer lip when said alignment fixture is assembled.

- [c19] The system of claim 1, further including a computer for controlling and coordinating vacuum pressure to said means for holding said substrate, operation of said two or more means for temporarily affixing, operation of said means for controlling said means for temporarily affixing, operation of said means for aligning, and operation of said means for temporarily fastening.
- [c20] The system of claim 1, wherein said mask is a metal mask.
- [c21] The system of claim 1, wherein said substrate is a semiconductor wafer.
- [c22] 22. The system of claim 1, wherein said mask is a solder bump evaporation mask.
- [c23] 23. A method for aligning a mask to a substrate comprising

in the order recited:

- (a) placing a bottom ring of an alignment fixture on an alignment tool;
- (b) loading a substrate onto a chuck;
- (c) securing said substrate on said chuck;
- (d) locating alignment targets on said substrate relative to fixed positions of a first X-Y stage and a rotational stage mounted on said first X-Y stage;
- (e) placing said mask on said bottom ring and placing a top ring of said alignment fixture on said mask, said top ring aligned to said bottom ring;
- (f) applying a clamping force of a first predetermined amount of force to said alignment fixture sufficient to prevent said mask from moving relative to said top and bottom rings;
- (g) locating alignment marks on said mask relative to a fixed position of a second X-Y-stage, said first X-Y stage and said table mounted to said second X-Y stage, X and Y orthogonal displacement directions associated with each of said first and second X-Y stages being co-aligned;
- (h) calculating an X distance in said X direction and a Y distance in said Y direction to move said first X-Y stage and an angle to rotate said rotational stage through in order to align said alignment marks to said alignment targets;
- (i) increasing the applied clamping force to a second predetermined amount of force, releasing said substrate from

said chuck, and increasing the applied clamping force to a third predetermined amount of force;

(j) temporarily fastening said alignment fixture containing said mask and said substrate together; and releasing said applied clamping force.

[c24] The method of claim 23, further including after step (e) passing alignment pins contained in at least two mask alignment pin mechanisms mounted to said table through openings in said table and said bottom and top rings and engaging mask alignment holes in said mask.

[c25] 25. The method of claim 23, wherein in steps (f) and (i) said first, second and third predetermined clamping forces are uniformly distributed along a perimeter of said alignment fixture.

[c26] The method of claim 23, wherein step (j) further includes simultaneously inserting removable spring clips onto lower portions of retaining posts extending below said bottom ring, said retaining posts fixed in and extending from said top ring and through retaining post holes in said mask and retaining post holes in said bottom ring.

[c27] The method of claim 26, wherein step (j) further includes compressing said removable spring clips prior to insertion of said removable spring clips onto said retaining posts.

[c28] The method of claim 23, further including after step (c) moving said first X-Y stage a first predetermined X distance in said X direction and a first predetermined Y distance in said Y direction and rotating said rotational stage through a predetermined angle.

[c29] The method of claim 23, further including after step (f) moving said second X-Y stage a second predetermined X distance in said X direction and a second predetermined Y distance in said Y direction.

[c30] The method of claim 23, wherein step (h) further includes determining locations of center points of alignment targets on said substrate alignment marks on said mask relative to a fixed position of said stage assembly using said pattern recognition system and calculating a distance to move said stage assembly in said first orthogonal direction, a distance to move said stage assembly in said second orthogonal direction and a angle to rotate said stage assembly through using said computer in order to align said center points of said alignment targets with said center points of said alignment marks.

[c31] The method of claim 23, wherein:  
said bottom ring includes an inner lip for supporting an interior region of said substrate and an outer lip for supporting a peripheral region of said mask, said inner lip higher than said outer lip;

retaining posts fixed in and extending from said top ring and through retaining post holes in said bottom ring; removable spring clips engaging said retaining posts; and when said removable spring clips are engaged in said retaining posts, said top ring presses said peripheral portion of said mask against said outer lip.

- [c32] The method of claim 23, wherein said mask is a metal solder bump evaporation mask and said substrate is a semiconductor wafer.
- [c33] A method of aligning a mask to a substrate comprising in the order recited:
  - (a) providing an alignment fixture for temporarily holding said mask and said substrate in fixed positions relative to each other;
  - (b) providing an alignment tool including a stage assembly and a table;
  - (c) placing a bottom ring of said alignment fixture on said table;
  - (d) securing said substrate on said chuck and locating alignment targets on said substrate relative to a fixed position of said stage assembly,
  - (e) placing said mask on said bottom ring and placing a top ring of said alignment fixture on said mask, said top ring aligned to said bottom ring;

- (f) applying a affixing force of a first predetermined amount of force to said alignment fixture sufficient to prevent said mask from moving;
- (g) locating alignment marks on said mask relative to a fixed position of said stage assembly;
- (h) moving said substrate relative to said mask in order to align said alignment marks to said alignment targets;
- (i) increasing the applied affixing force to a second predetermined amount of force, releasing said substrate from said chuck, increasing the applied affixing force to a third predetermined amount of force;
- (j) temporarily fastening said alignment fixture containing said mask and said substrate together; and
- (k) releasing said applied affixing force.

[c34] The method of claim 33, wherein said first and second directions are orthogonal to each other and parallel to said table.

[c35] The method of claim 1, wherein said axis is perpendicular to said table.

[c36] The method of claim 33, wherein said alignment tool further includes an additional stage assembly moveable in said first and second directions, said stage assembly and said table mounted on said additional stage assembly, movement of said additional stage assembly in said first and second directions

controlled by said means for aligning.

- [c37] The method of claim 33, wherein said means for holding said substrate is a vacuum chuck including a circular array of O-rings adjacent to a perimeter of said vacuum chuck, each O-ring extending above a top surface of said chuck and surrounding a vacuum port.
- [c38] The method of claim 37, wherein said alignment tool further includes means for releasing vacuum pressure applied to said vacuum chuck when said affixing force reaches a predetermined value.
- [c39] The method of claim 33, further including after step (f) passing alignment pins contained in at least two mask alignment pin mechanisms mounted to said table through openings in said table and said alignment fixture and engaging mask alignment holes in said mask.
- [c40] The method of claim 39, wherein said alignment pins are spring loaded and can move in a third direction perpendicular to said table.
- [c41] The method of claim 39, wherein said mask alignment holes comprise a circular alignment hole and a slot.
- [c42] 42. The method of claim 39, wherein said mask alignment holes are diametrically opposed.

[c43] The method of claim 33, wherein said means for temporarily affixing comprise two or more clamping mechanisms that are uniformly spaced around a perimeter of said alignment fixture and said first, second and third predetermined affixing forces are uniformly distributed along said perimeter of said alignment fixture.

[c44] The method of claim 43, wherein said clamping mechanisms further include clamping fingers for compressing and clamping said alignment fixture and push rods for moving said clamping fingers.

[c45] The method of claim 44, wherein said push rods are simultaneously activated by a rotatable ring moveable in a third direction perpendicular to said table.

[c46] The method of claim 33, wherein step (j) further includes temporarily inserting removable spring clips onto lower portions of retaining posts extending below a bottom ring of said alignment fixture, said retaining posts fixed in and extending from a top ring portion of said alignment fixture and through retaining post holes in said mask and retaining post holes in said bottom ring.

[c47] The method of claim 46, wherein said removable spring clips are simultaneously inserted onto said retaining posts.

[c48] The method of claim 33, wherein step (j) further includes

compressing said removable spring clips prior to insertion of said removable spring clips onto said retaining posts.

[c49] The method of claim 33, wherein step (h) further includes determining locations of center points of alignment targets on said substrate alignment marks on said mask relative to a fixed position of said stage assembly using said pattern recognition system and calculating a distance to move said stage assembly in said first direction, a distance to move said stage assembly in said second direction and a angle to rotate said stage assembly through using said computer in order to align said center points of said alignment targets with said center points of said alignment marks.

[c50] The method of claim 33, wherein said alignment fixture comprises:  
a top ring;  
a bottom ring having an inner lip for supporting an interior region of said substrate and an outer lip for supporting a peripheral region of said mask, said inner lip higher than said outer lip;  
retaining posts fixed in and extending from said top ring and through retaining post holes in said bottom ring;  
removable spring clips engaging said retaining posts;  
wherein said top ring presses said peripheral portion of said mask against said outer lip when said alignment fixture is

assembled.

- [c51] The method of claim 33, wherein:
  - steps (d) further includes controlling vacuum pressure to said chuck using said computer;
  - step (e) further includes controlling the amount of force exerted by said means for affixing using said computer; and
  - step (i) further includes controlling the operation of said means for temporarily fastening using said computer.
- [c52] The method of claim 33, wherein said mask is a metal mask.
- [c53] The method of claim 33, wherein said substrate is a semiconductor wafer.
- [c54] 54. The method of claim 33, wherein said mask is a solder bump evaporation mask.
- [c55] 55. The method of claim 33, wherein said alignment tool further comprises:
  - means for holding said substrate at a bottom surface of said substrate, said means for holding protruding through an opening in said table and an opening in said alignment fixture,
  - said means for holding fixedly mounted on said stage assembly, said stage assembly moveable in first and second directions and rotatable about an axis relative to said table;
  - for temporarily affixing said alignment fixture containing said mask and said substrate to said table, said means for

temporarily affixing applying a substantially uniform force around a perimeter of said alignment fixture; pattern recognition system including a camera and a computer, said computer controlling movements of said stage assembly in said first and second directions and rotational movement; and for temporarily fastening said alignment fixture together;